FIG. 1

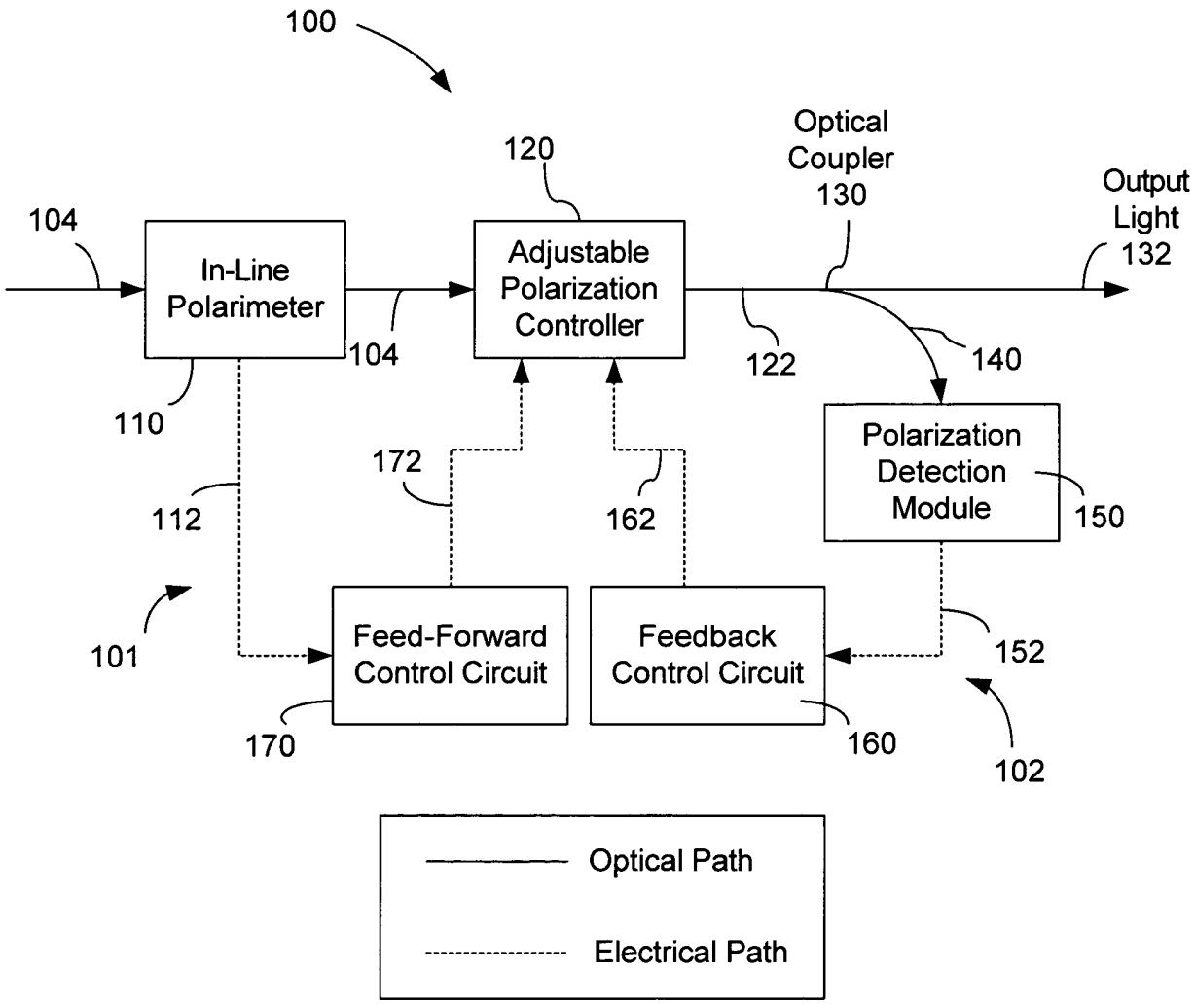

100
120
Optical
Coupler
130
Output
Light
132
104
In-Line
Polarimeter
Adjustable
Polarization
Controller
104
122
140
110
172
162
Polarization
Detection
Module
150
112
101
Feed-Forward
Control Circuit
Feedback
Control Circuit
152
170
160
102
Optical Path
Electrical Path

FIG. 2

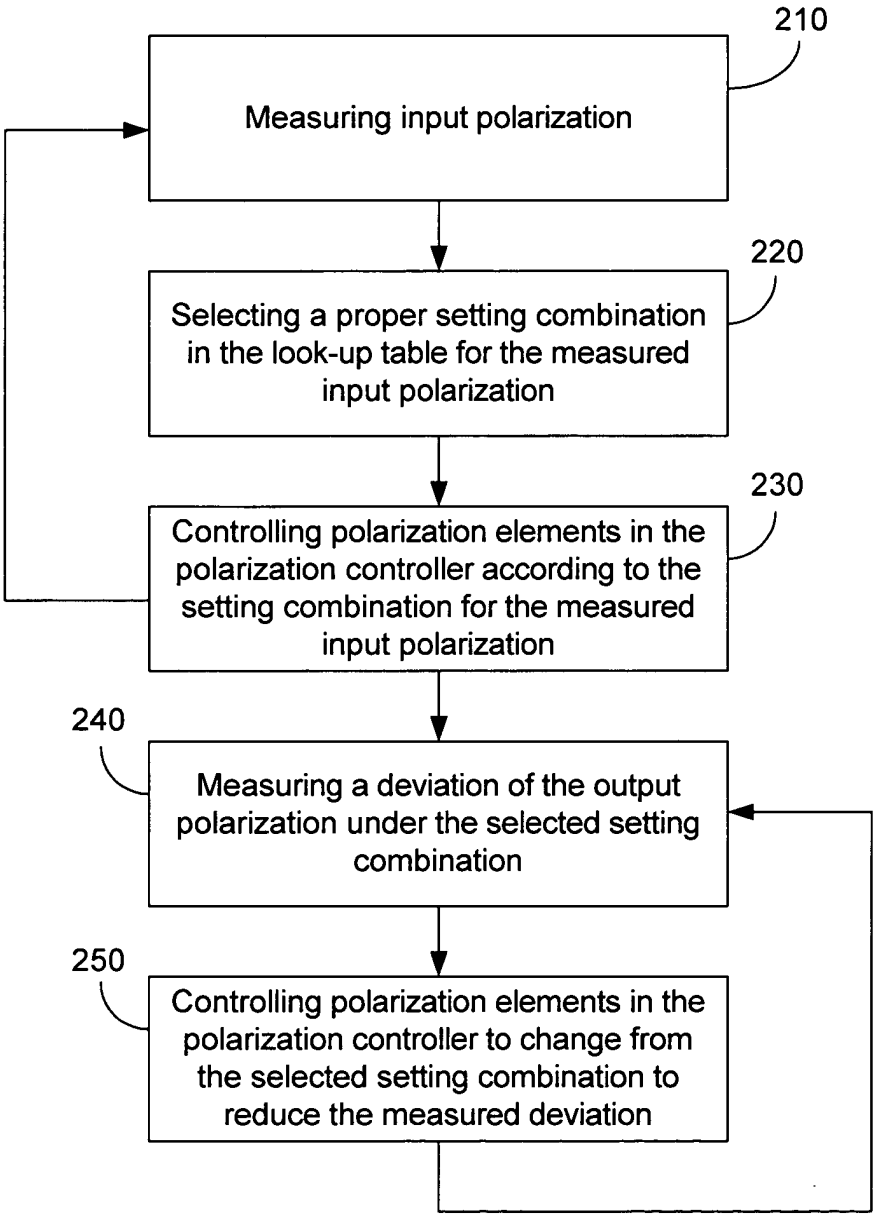

210
Measuring input polarization
220
Selecting a proper setting combination in the look-up table for the measured input polarization
230
Controlling polarization elements in the polarization controller according to the setting combination for the measured input polarization
240
Measuring a deviation of the output polarization under the selected setting combination
250
Controlling polarization elements in the polarization controller to change from the selected setting combination to reduce the measured deviation

FIG. 3

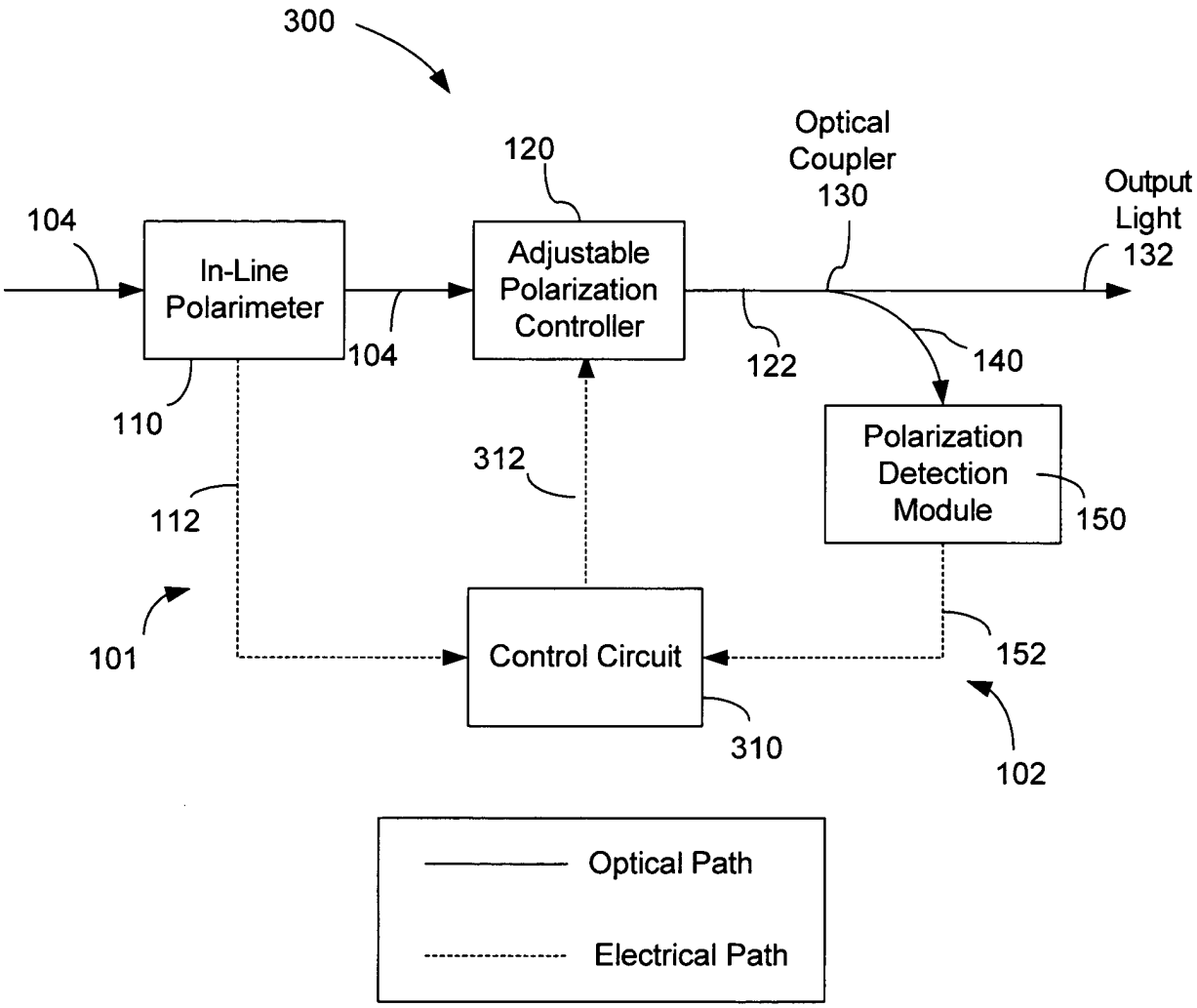

300
120
Optical Coupler 130
Output Light 132
104
In-Line Polarimeter
Adjustable Polarization Controller
104
122
140
110
312
Polarization Detection Module
150
112
101
Control Circuit
152
310
102
Optical Path
Electrical Path

FIG. 4A

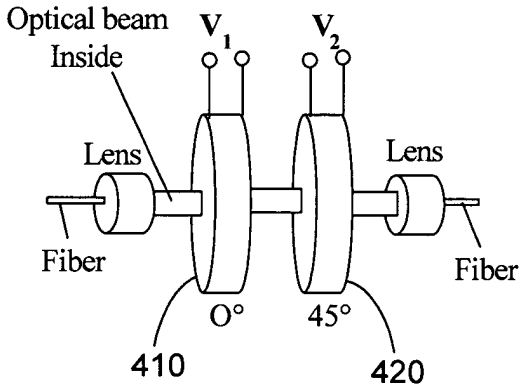

Optical beam
Inside
V1
V2
Lens
Lens
Fiber
Fiber
O°
45°
410
420

FIG. 4B

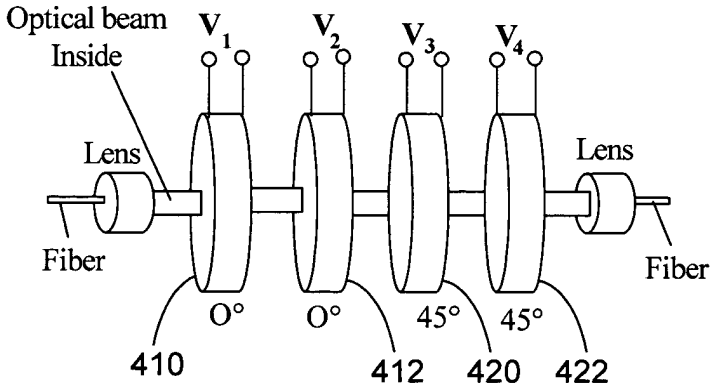

Optical beam
Inside
V1
V2
V3
V4
Lens
Lens
Fiber
Fiber
O°
O°
45°
45°
410
412
420
422

FIG. 5A

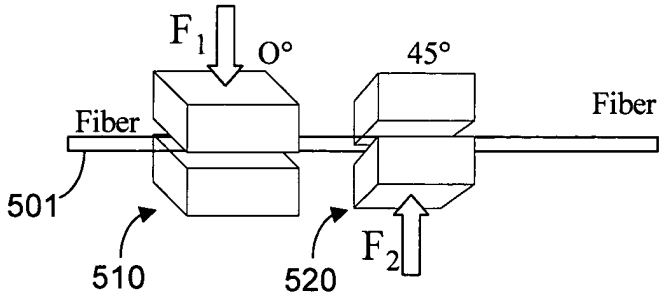

F1
O°
45°
Fiber
Fiber
501
510
520
F2

FIG. 5B

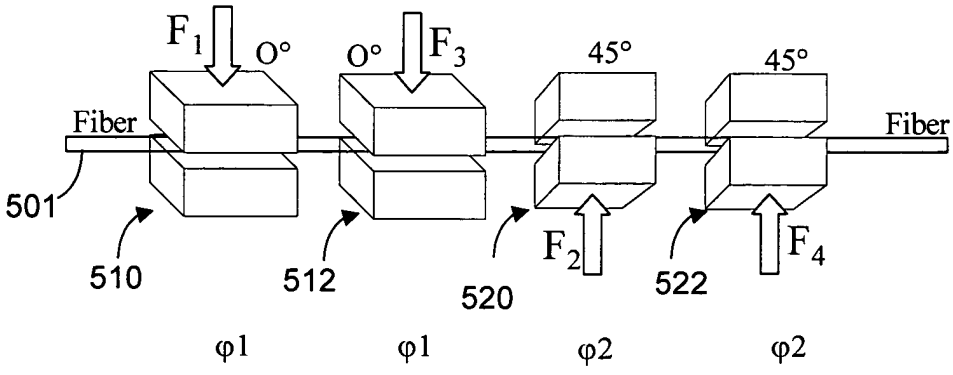

F1
O°
O°
F3
45°
45°
Fiber
Fiber
501
510
512
520
522
F2
F4
φ1
φ1
φ2
φ2

FIG. 6

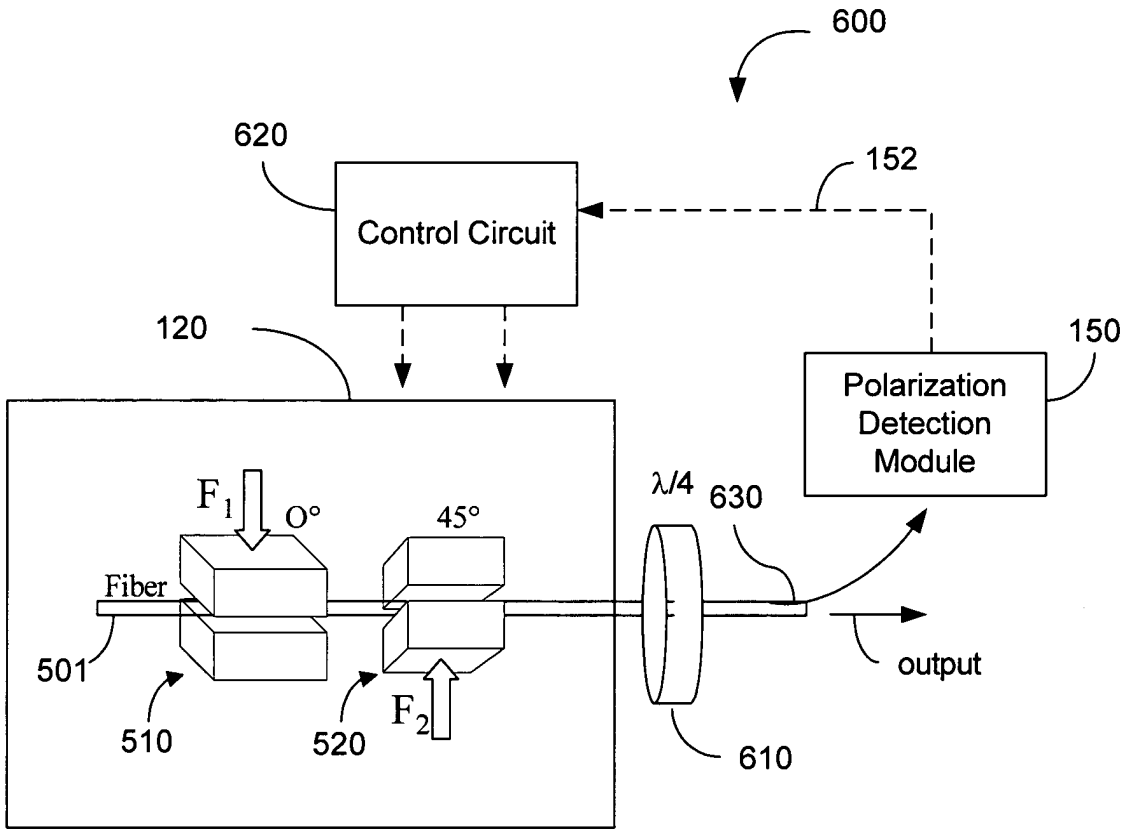

600
620
Control Circuit
152
120
150
Polarization
Detection
Module
F_1
O°
45°
λ/4
630
Fiber
501
output
510
520
F_2
610

FIG. 7

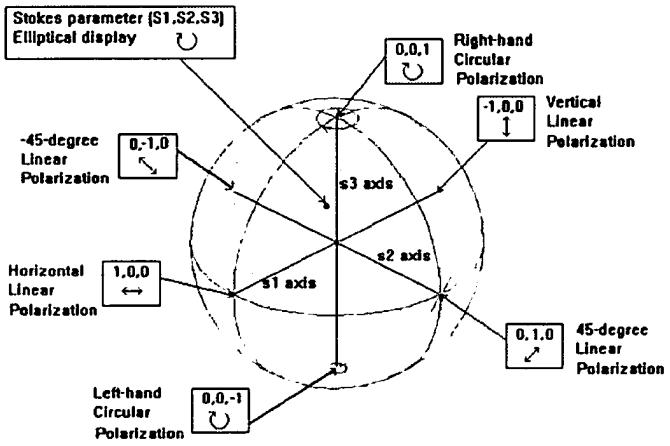

Stokes parameter (S1,S2,S3)
Elliptical display
0,0,1
Right-hand
Circular
Polarization
-1,0,0
Vertical
Linear
Polarization
-45-degree
Linear
Polarization
0,-1,0
s3 axis
s2 axis
s1 axis
Horizontal
Linear
Polarization
1,0,0
0,1,0
45-degree
Linear
Polarization
Left-hand
Circular
Polarization
0,0,-1

FIG. 8

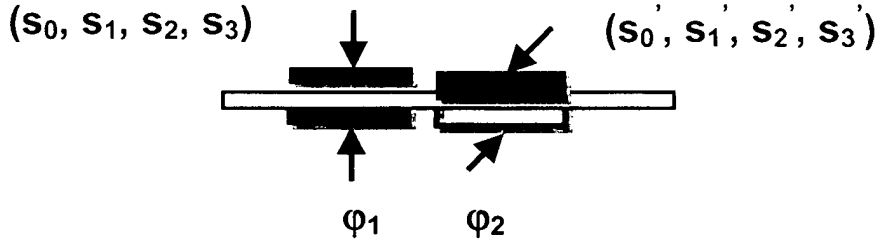


FIG. 9

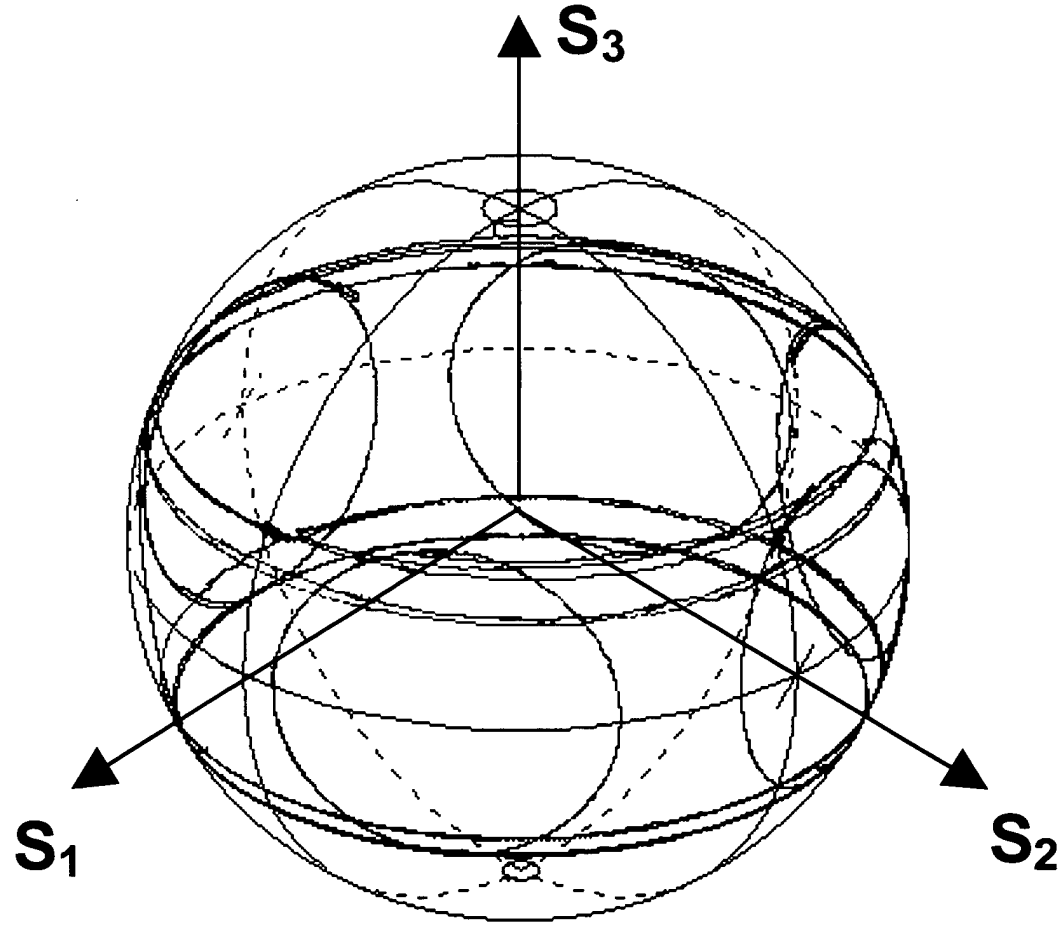


FIG. 10

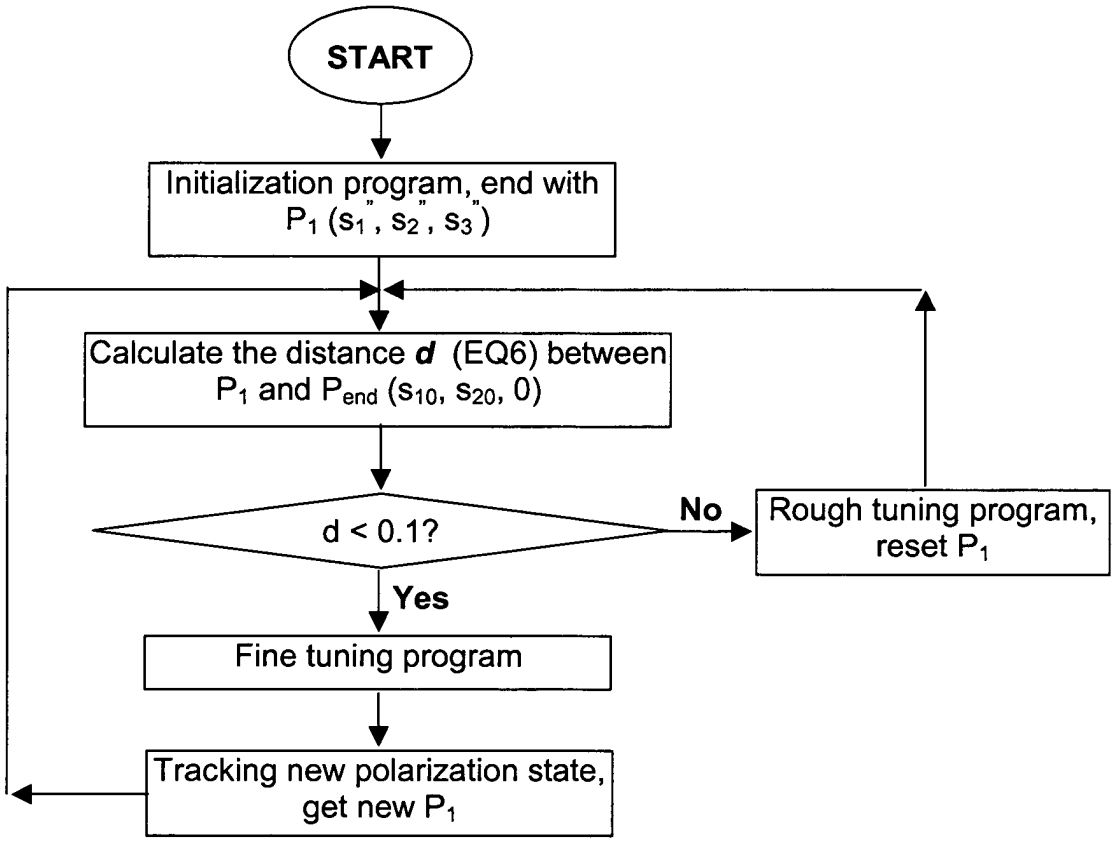

START
Initialization program, end with P_1 (s_1", s_2", s_3")
Calculate the distance *d* (EQ6) between P_1 and P_{end} (s_{10}, s_{20}, 0)
d < 0.1?
No
Rough tuning program, reset P_1
Yes
Fine tuning program
Tracking new polarization state, get new P_1

FIG. 11

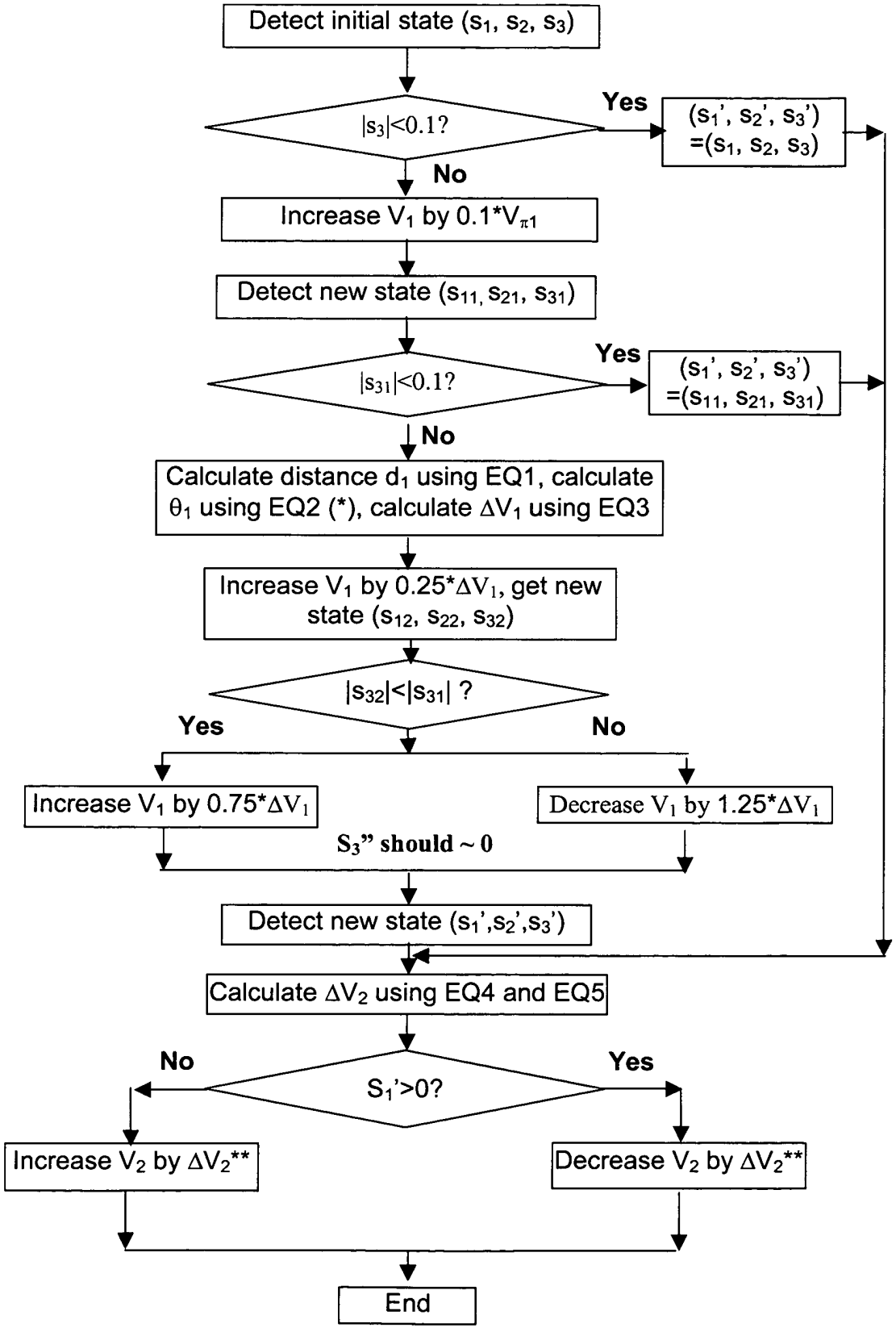
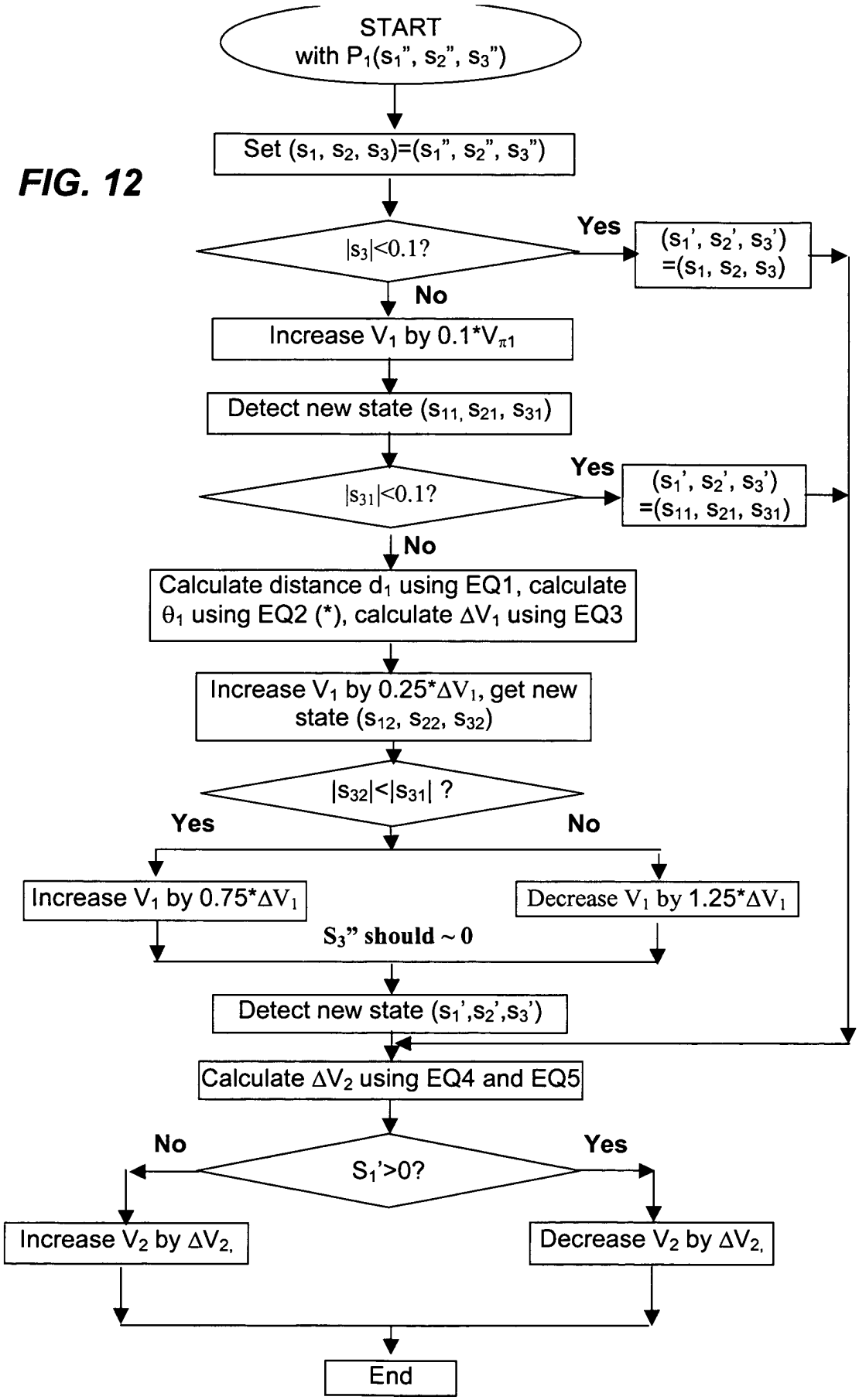

Detect initial state (s_1, s_2, s_3)
$|s_3|<0.1$?
Yes
(s_1', s_2', s_3') =(s_1, s_2, s_3)
No
Increase V_1 by $0.1*V_{\pi 1}$
Detect new state (s_{11}, s_{21}, s_{31})
$|s_{31}|<0.1$?
Yes
(s_1', s_2', s_3') =(s_{11}, s_{21}, s_{31})
No
Calculate distance d_1 using EQ1, calculate θ_1 using EQ2 (*), calculate ΔV_1 using EQ3
Increase V_1 by $0.25*\Delta V_1$, get new state (s_{12}, s_{22}, s_{32})
$|s_{32}|<|s_{31}|$?
Yes
No
Increase V_1 by $0.75*\Delta V_1$
Decrease V_1 by $1.25*\Delta V_1$
S_3" should ~ 0
Detect new state (s_1',s_2',s_3')
Calculate ΔV_2 using EQ4 and EQ5
No
$S_1'>0$?
Yes
Increase V_2 by ΔV_2**
Decrease V_2 by ΔV_2**
End

FIG. 12


START with $P_1(s_1'', s_2'', s_3'')$
Set $(s_1, s_2, s_3)=(s_1'', s_2'', s_3'')$
$|s_3|<0.1$?
Yes
$(s_1', s_2', s_3')=(s_1, s_2, s_3)$
No
Increase V_1 by $0.1*V_{\pi 1}$
Detect new state (s_{11}, s_{21}, s_{31})
$|s_{31}|<0.1$?
Yes
$(s_1', s_2', s_3')=(s_{11}, s_{21}, s_{31})$
No
Calculate distance d_1 using EQ1, calculate θ_1 using EQ2 (*), calculate ΔV_1 using EQ3
Increase V_1 by $0.25*\Delta V_1$, get new state (s_{12}, s_{22}, s_{32})
$|s_{32}|<|s_{31}|$?
Yes
No
Increase V_1 by $0.75*\Delta V_1$
Decrease V_1 by $1.25*\Delta V_1$
S_3'' should ~ 0
Detect new state (s_1', s_2', s_3')
Calculate ΔV_2 using EQ4 and EQ5
No
$S_1'>0$?
Yes
Increase V_2 by ΔV_2,
Decrease V_2 by ΔV_2,
End

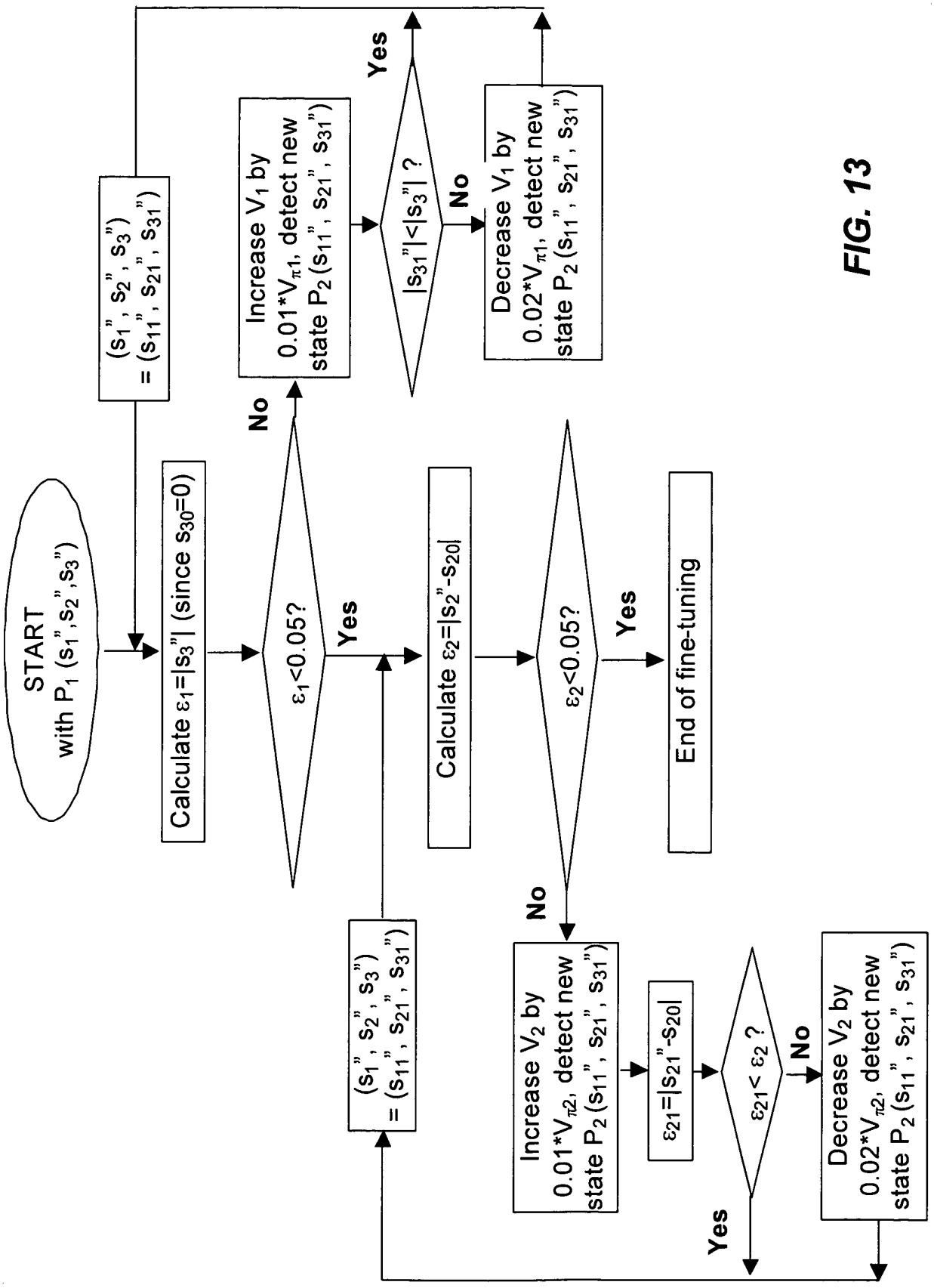

START
with P_1 (s_1", s_2", s_3")
Calculate ε_1=|s_3"| (since s_{30}=0)
ε_1<0.05?
No
Yes
Increase V_1 by 0.01*$V_{\pi 1}$, detect new state P_2 (s_{11}", s_{21}", s_{31}")
|s_{31}"|<|s_3"| ?
Yes
No
Decrease V_1 by 0.02*$V_{\pi 1}$, detect new state P_2 (s_{11}", s_{21}", s_{31}")
(s_1", s_2", s_3") = (s_{11}", s_{21}", s_{31}")
Calculate ε_2=|s_2"-s_{20}|
ε_2<0.05?
No
Yes
Increase V_2 by 0.01*$V_{\pi 2}$, detect new state P_2 (s_{11}", s_{21}", s_{31}")
ε_{21}=|s_{21}"-s_{20}|
ε_{21}< ε_2 ?
No
Yes
Decrease V_2 by 0.02*$V_{\pi 2}$, detect new state P_2 (s_{11}", s_{21}", s_{31}")
(s_1", s_2", s_3") = (s_{11}", s_{21}", s_{31}")
End of fine-tuning

FIG. 13

FIG. 14

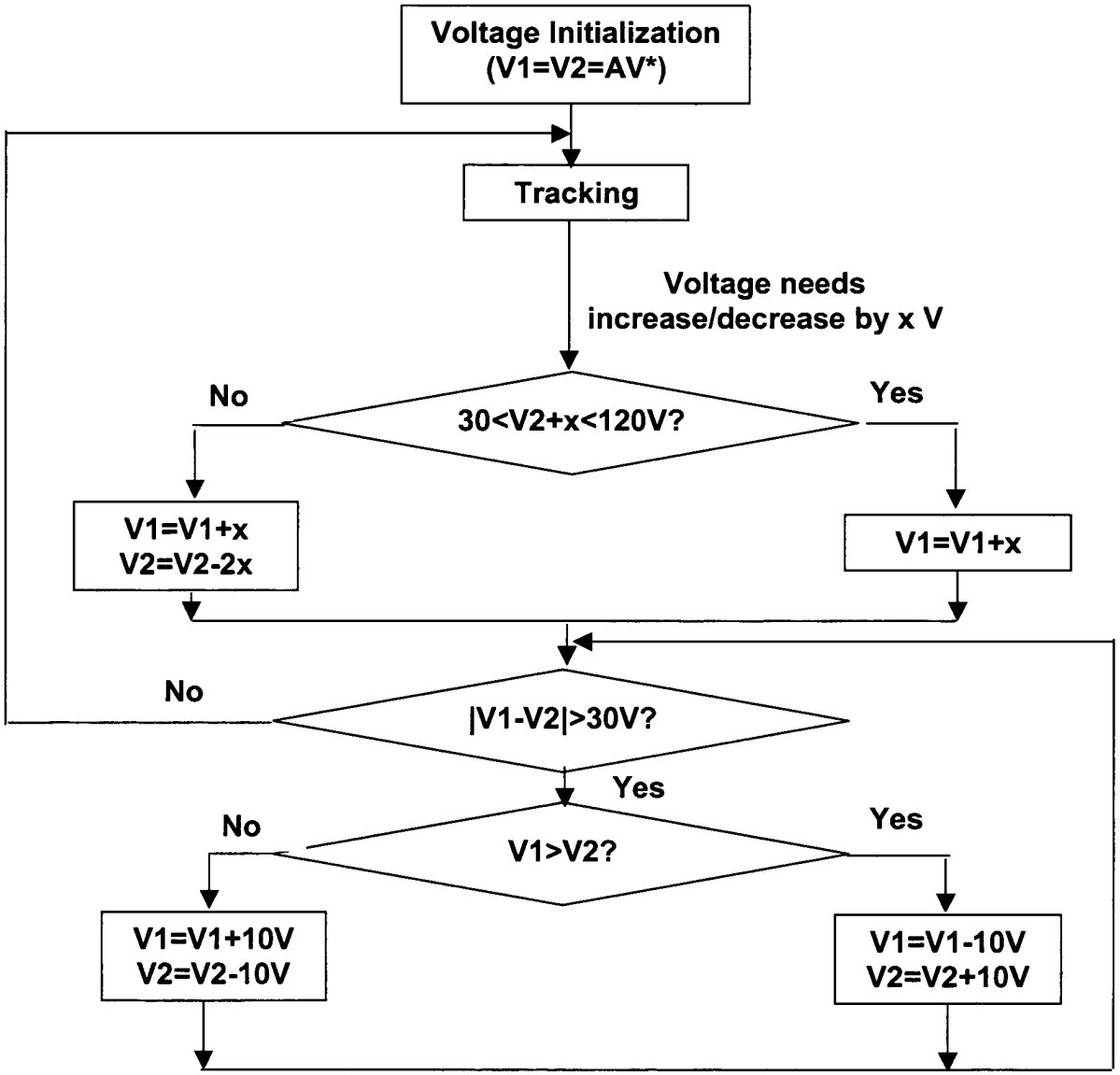
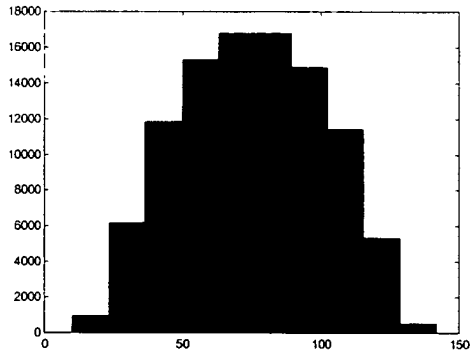

Voltage Initialization
(V1=V2=AV*)
Tracking
Voltage needs
increase/decrease by x V
No
30<V2+x<120V?
Yes
V1=V1+x
V2=V2-2x
V1=V1+x
No
|V1-V2|>30V?
Yes
No
V1>V2?
Yes
V1=V1+10V
V2=V2-10V
V1=V1-10V
V2=V2+10V

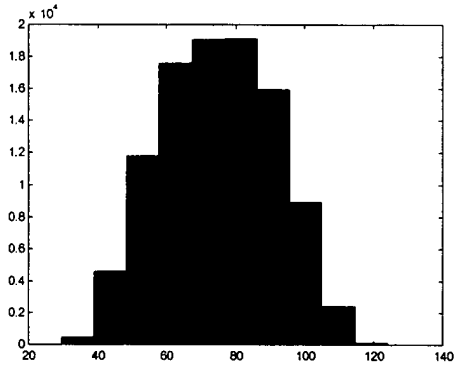
FIG. 15A



V1

(max=142V)

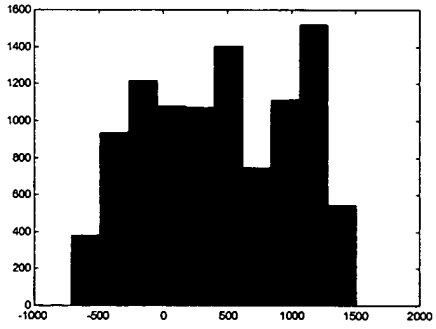
FIG. 15B



V2

(max=124V)

FIG. 15C



V

FIG. 16

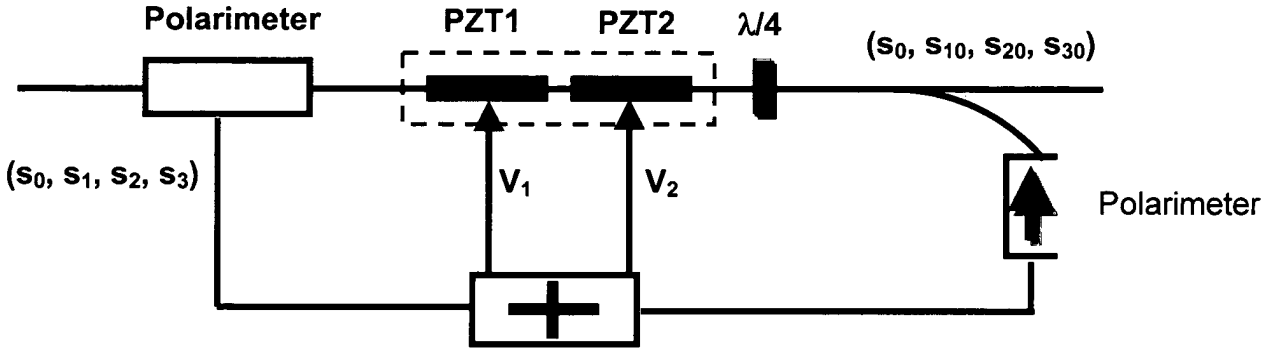


FIG. 17A

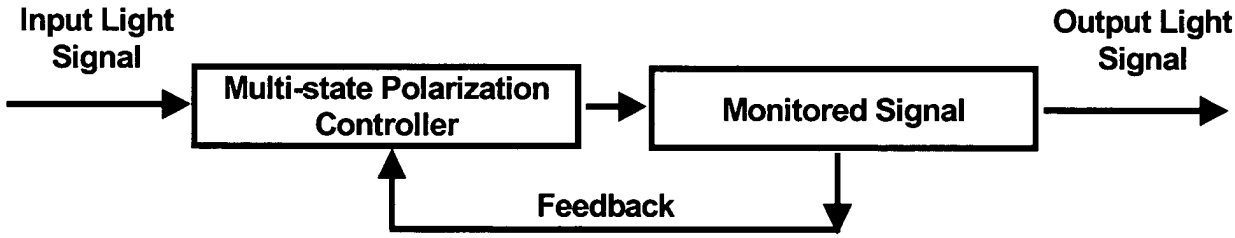


FIG. 17B

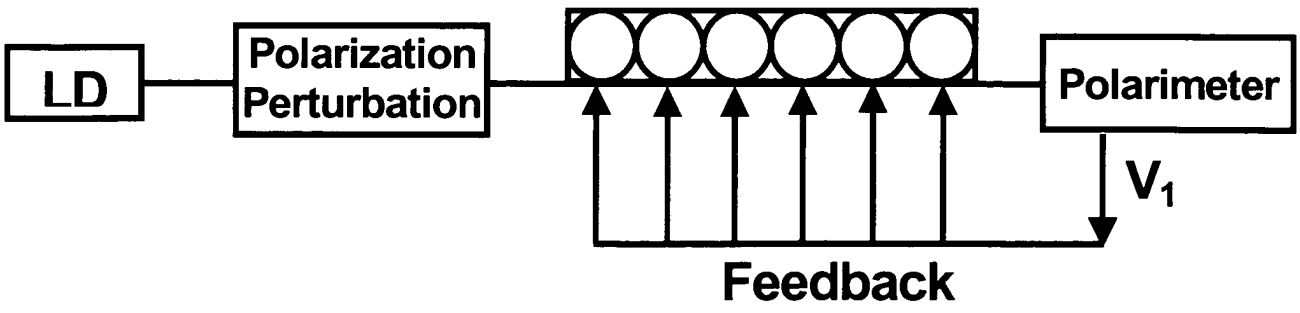


FIG. 18

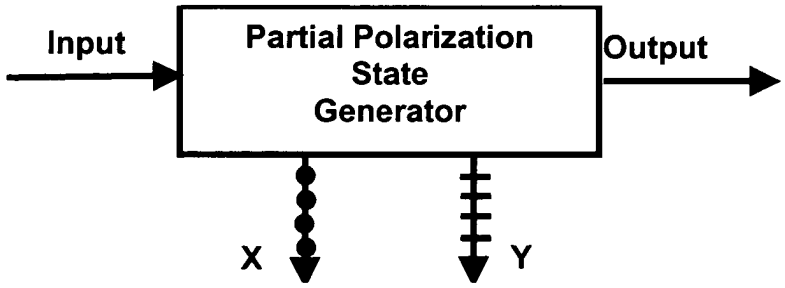
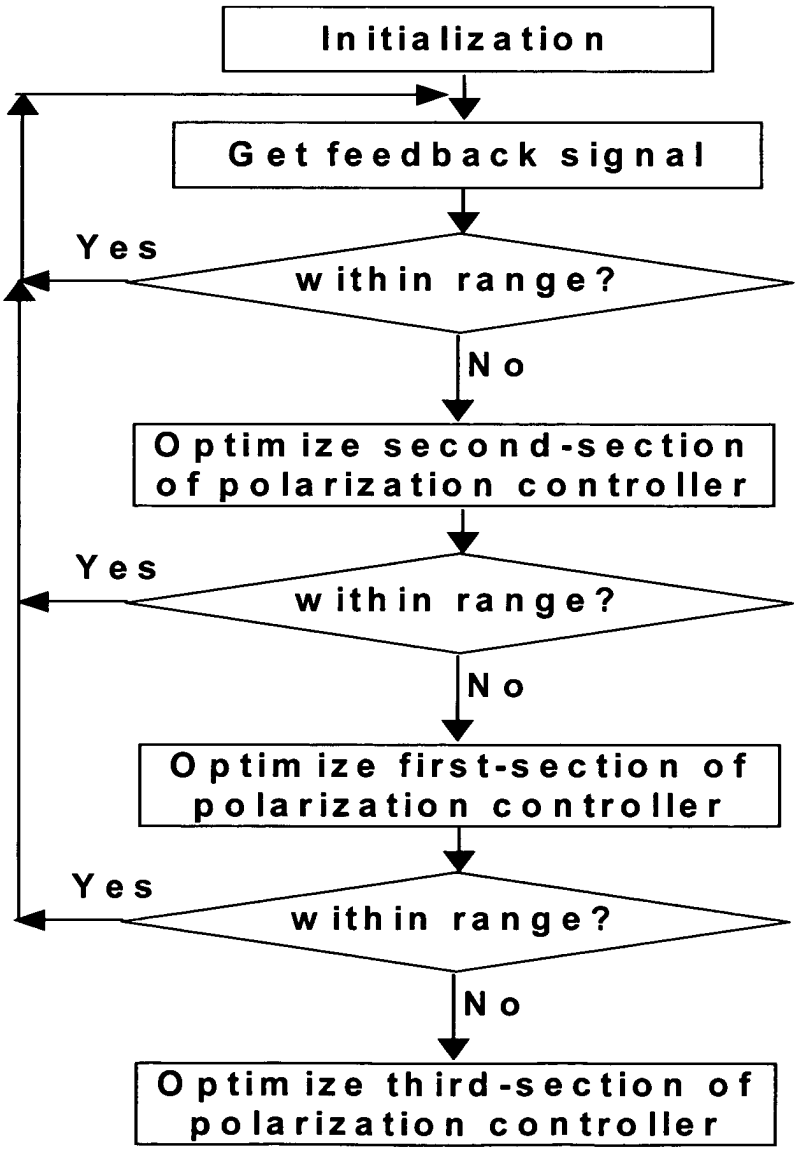

Input
Partial Polarization State Generator
Output
X
Y

FIG. 19


Initialization
Get feedback signal
Yes
within range?
No
Optimize second-section of polarization controller
Yes
within range?
No
Optimize first-section of polarization controller
Yes
within range?
No
Optimize third-section of polarization controller

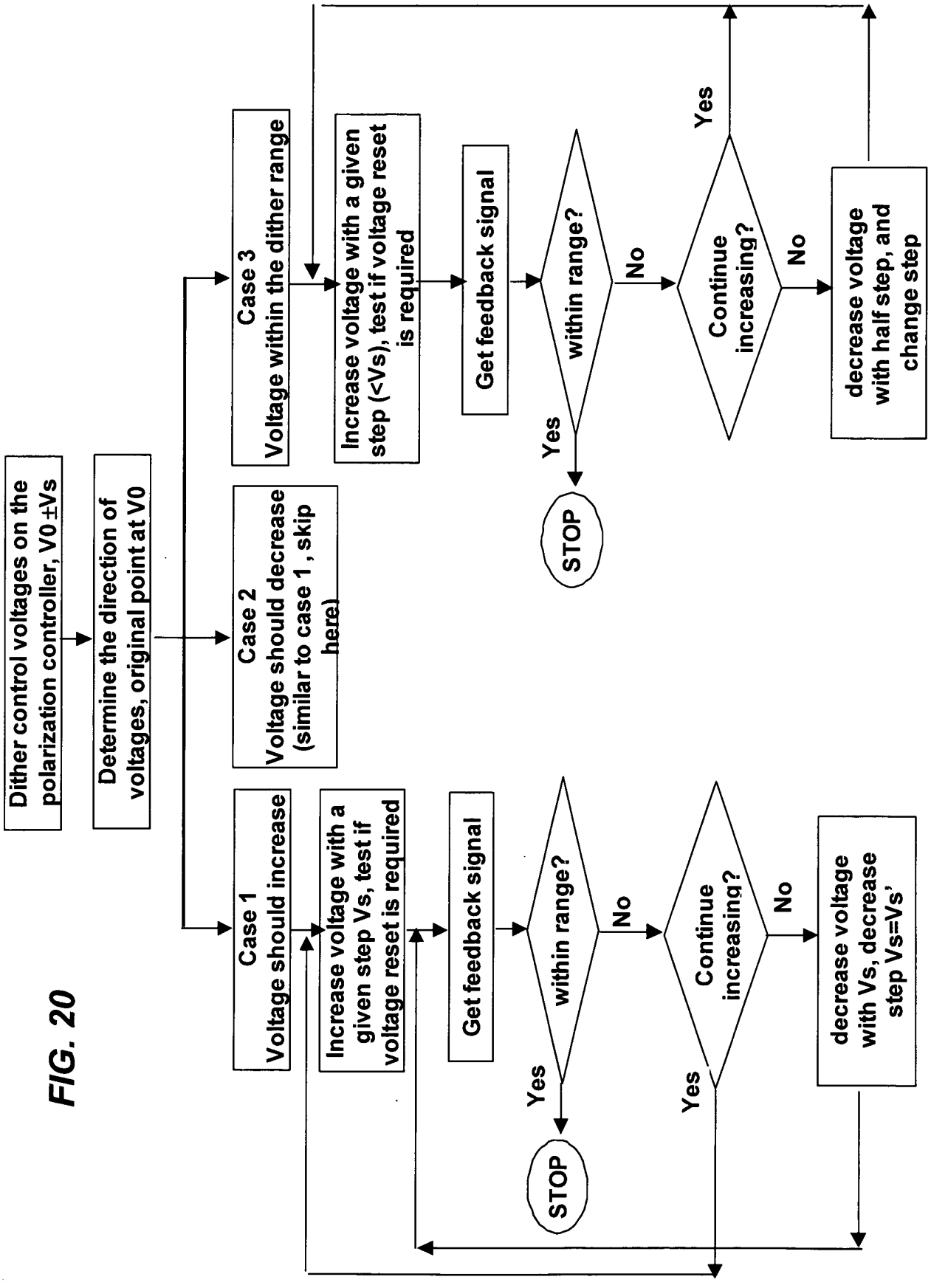

Dither control voltages on the polarization controller, V0 ±Vs
Determine the direction of voltages, original point at V0
Case 1 Voltage should increase
Case 2 Voltage should decrease (similar to case 1 , skip here)
Case 3 Voltage within the dither range
Increase voltage with a given step Vs, test if voltage reset is required
Increase voltage with a given step (<Vs), test if voltage reset is required
Get feedback signal
Get feedback signal
within range?
within range?
Yes
No
STOP
STOP
Continue increasing?
Continue increasing?
Yes
No
decrease voltage with Vs, decrease step Vs=Vs'
decrease voltage with half step, and change step

FIG. 20

FIG. 21

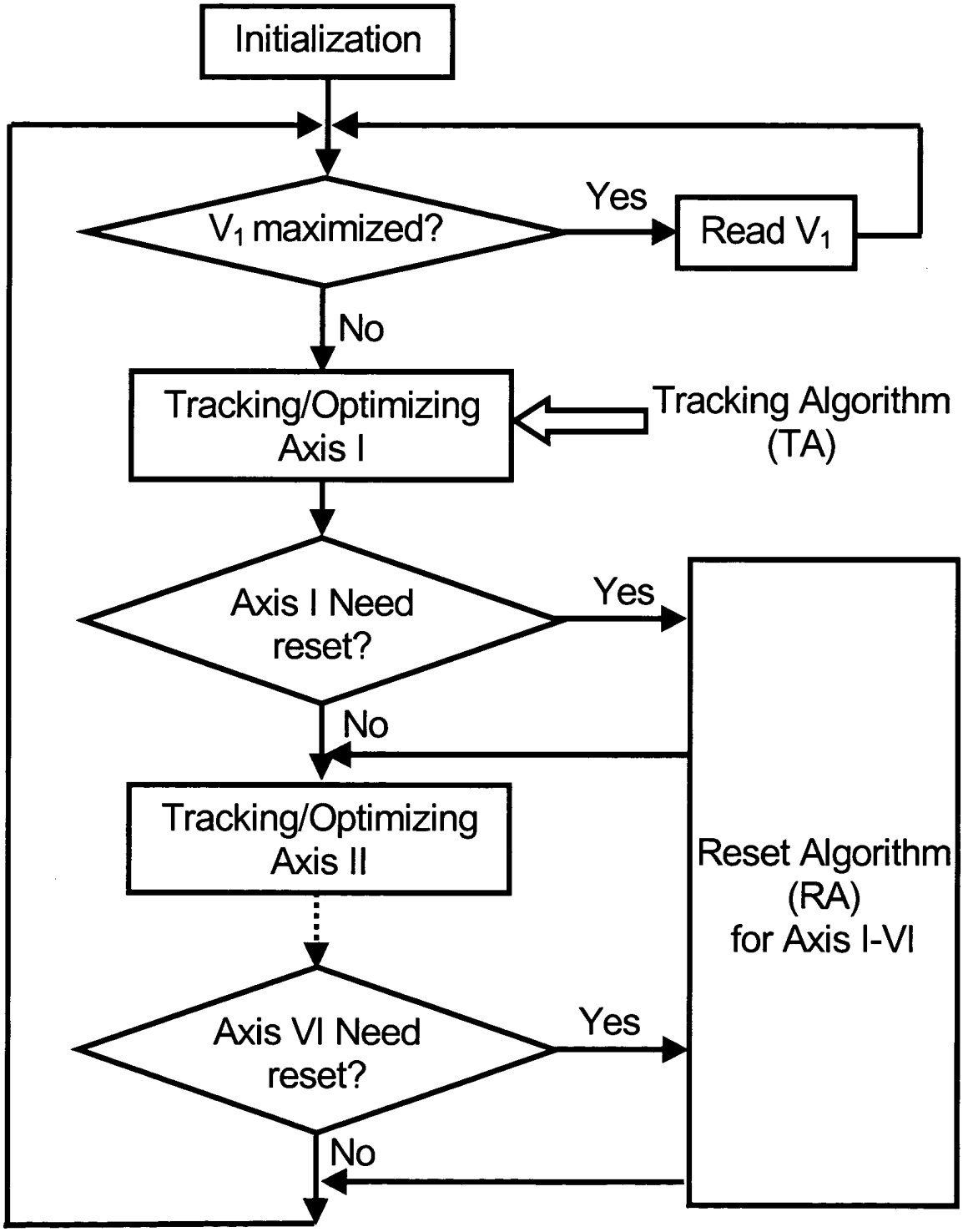

Initialization
V1 maximized?
Yes
Read V1
No
Tracking/Optimizing Axis I
Tracking Algorithm (TA)
Axis I Need reset?
Yes
No
Tracking/Optimizing Axis II
Reset Algorithm (RA) for Axis I-VI
Axis VI Need reset?
Yes
No

FIG. 22

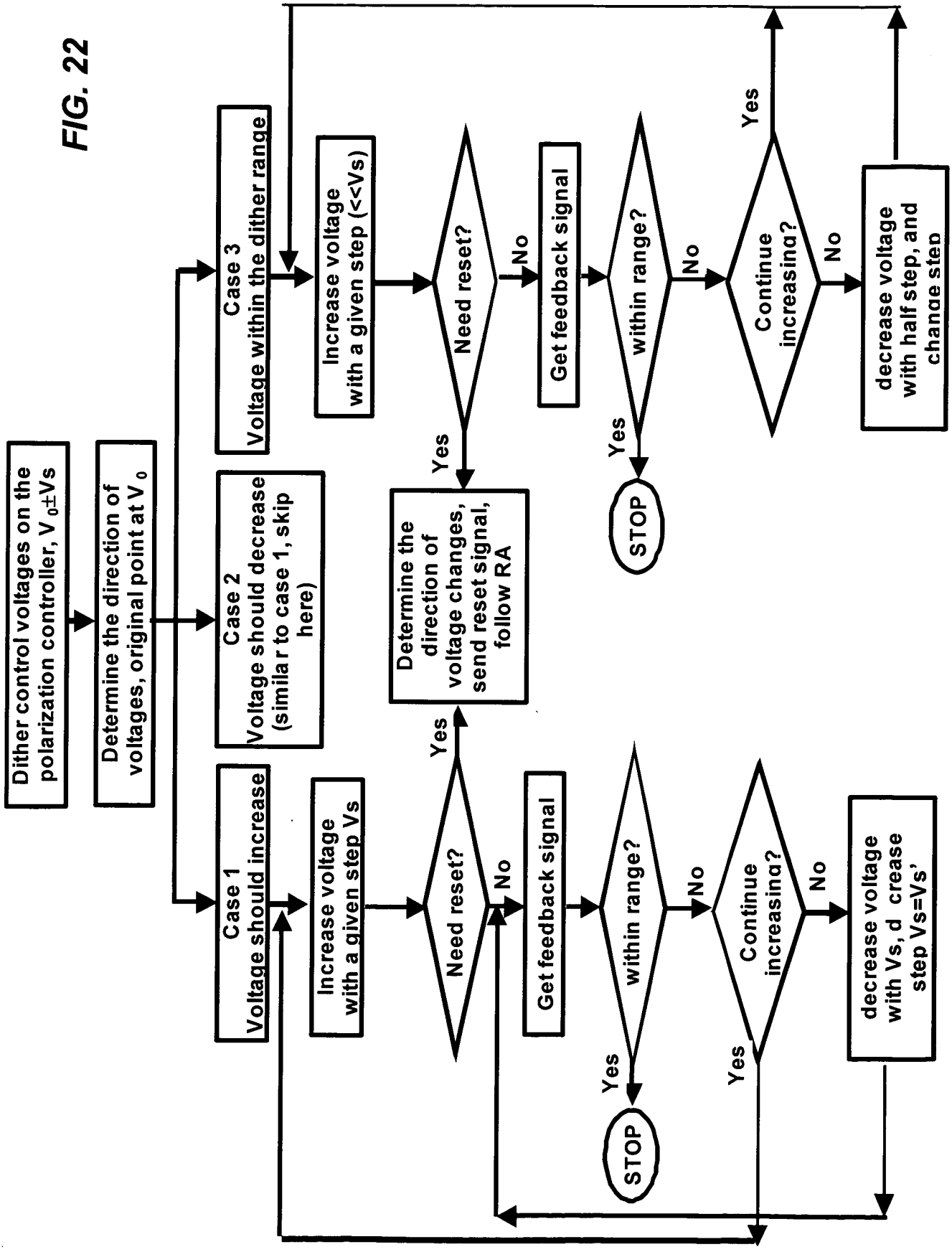

Dither control voltages on the polarization controller, $V_0 \pm Vs$
Determine the direction of voltages, original point at V_0
Case 1 Voltage should increase
Case 2 Voltage should decrease (similar to case 1, skip here)
Case 3 Voltage within the dither range
Increase voltage with a given step Vs
Increase voltage with a given step (<<Vs)
Need reset?
Yes
No
Determine the direction of voltage changes, send reset signal, follow RA
Get feedback signal
within range?
Yes
STOP
No
Continue increasing?
Yes
No
decrease voltage with Vs, d crease step Vs=Vs'
decrease voltage with half step, and change step

FIG. 23

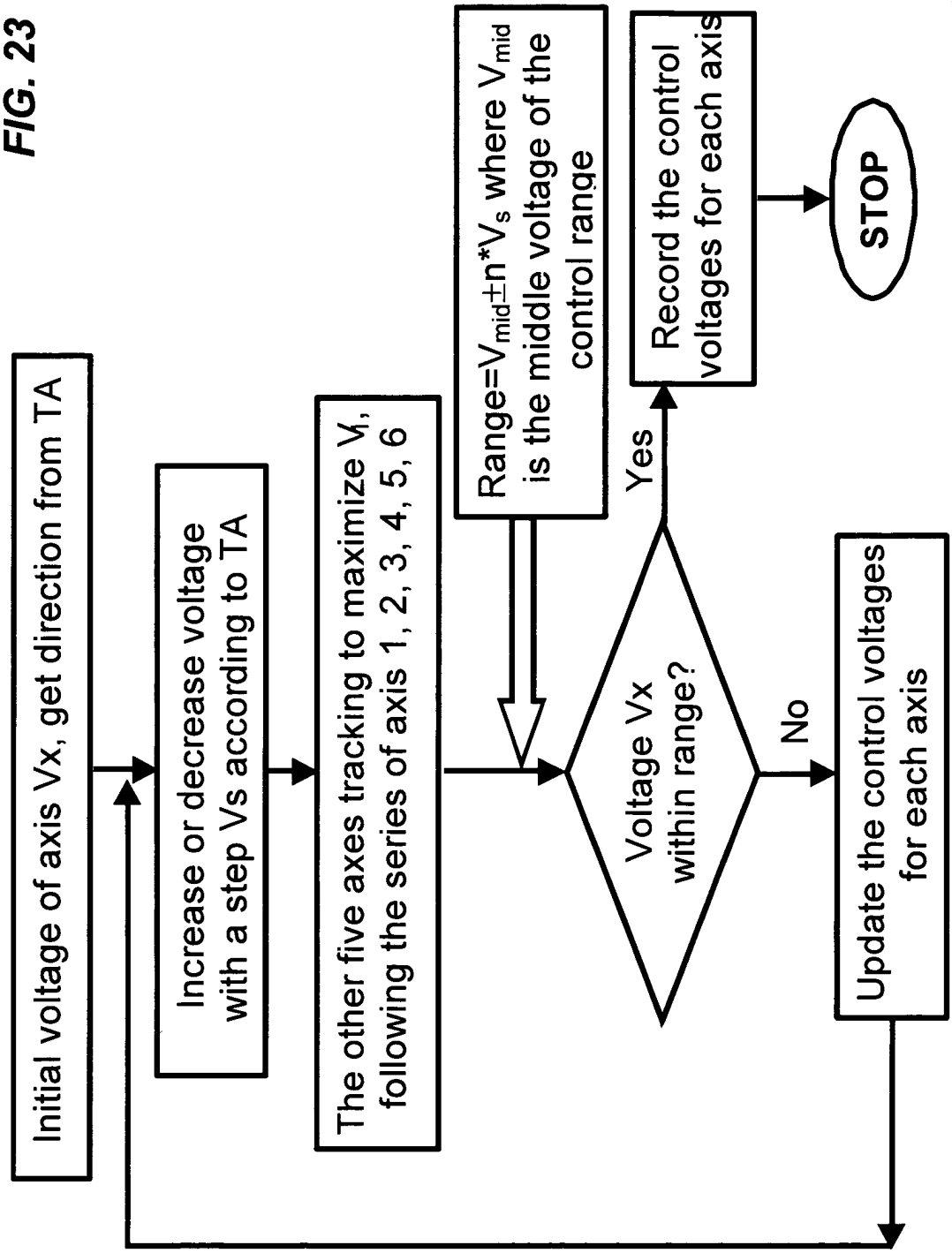

Initial voltage of axis Vx, get direction from TA
Increase or decrease voltage with a step Vs according to TA
The other five axes tracking to maximize Vi, following the series of axis 1, 2, 3, 4, 5, 6
Range=Vmid±n*Vs where Vmid is the middle voltage of the control range
Voltage Vx within range?
Yes
No
Record the control voltages for each axis
Update the control voltages for each axis
STOP

FIG. 24

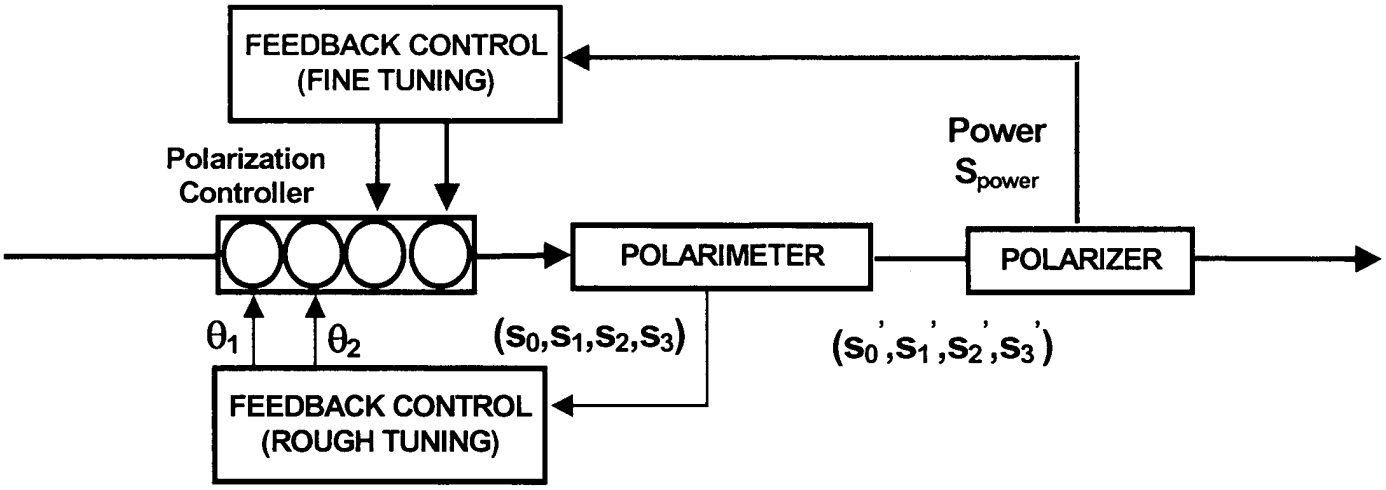


FIG. 25

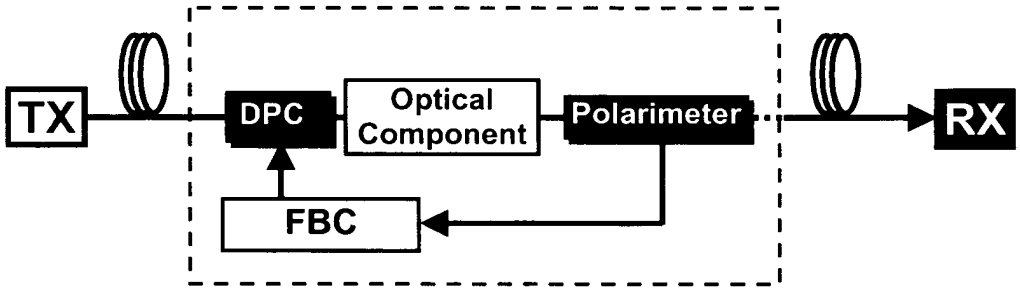


FIG. 26

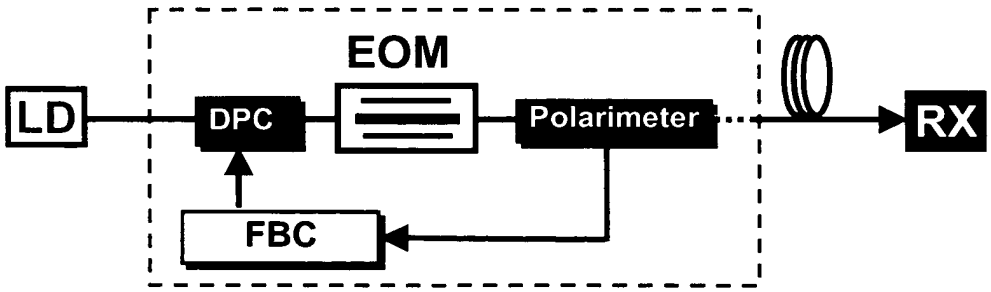


FIG. 27

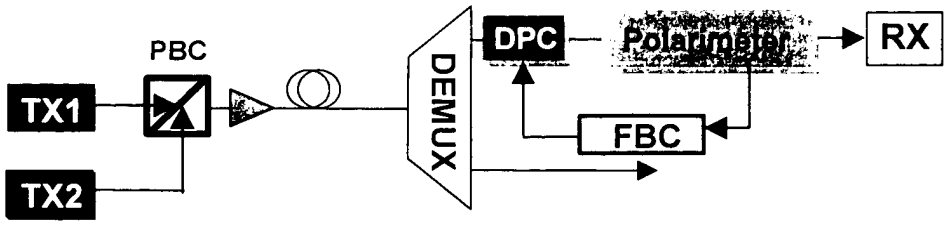


FIG. 28

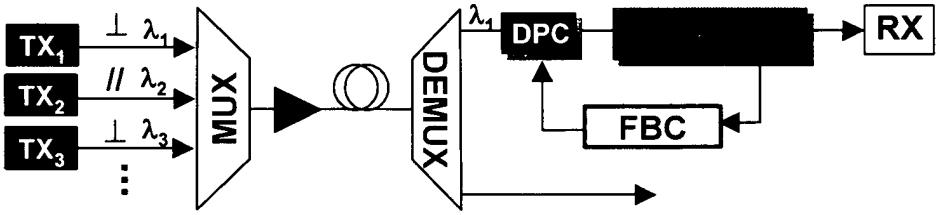


FIG. 29

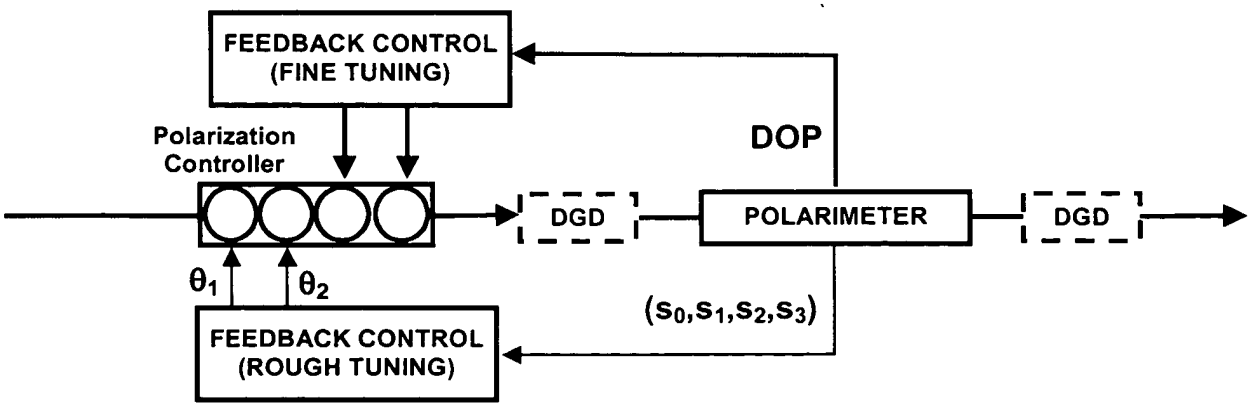


FIG. 31A

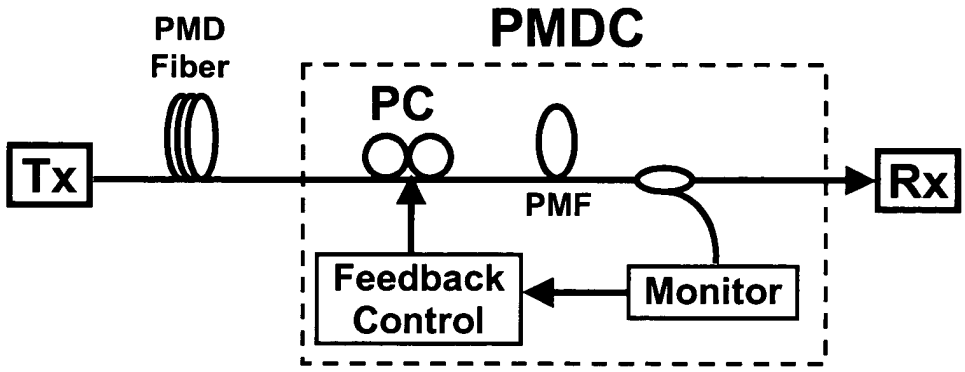


FIG. 31B

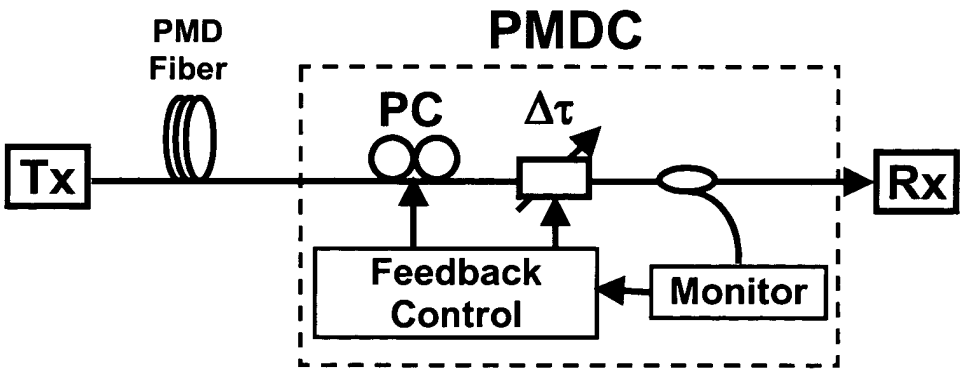


FIG. 32

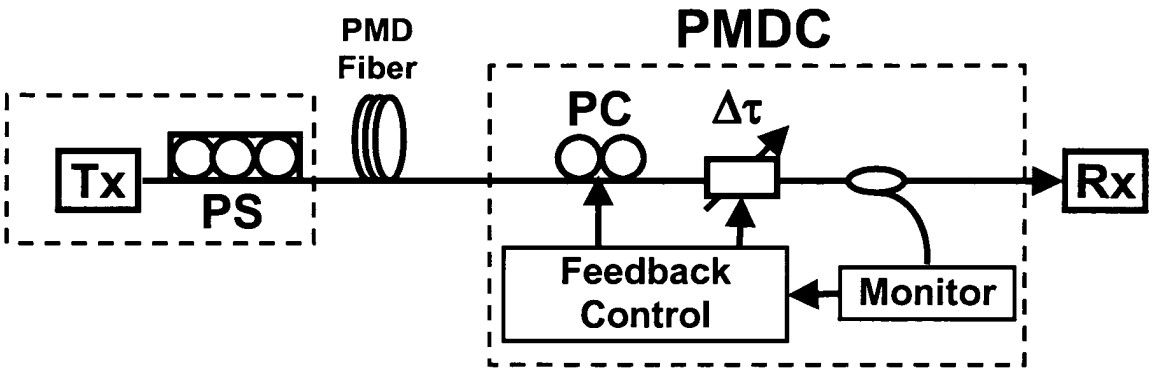

PMD
Fiber
PMDC
PC
Δτ
Tx
PS
Rx
Feedback
Control
Monitor

FIG. 33

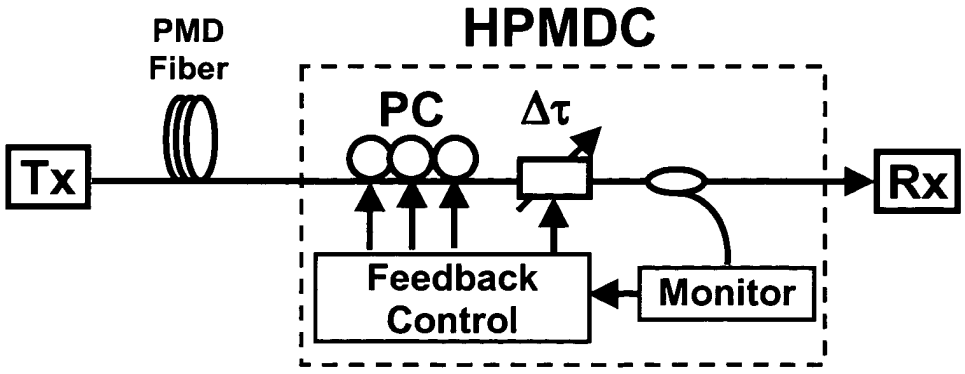

PMD
Fiber
HPMDC
PC
Δτ
Tx
Rx
Feedback
Control
Monitor

FIG. 34

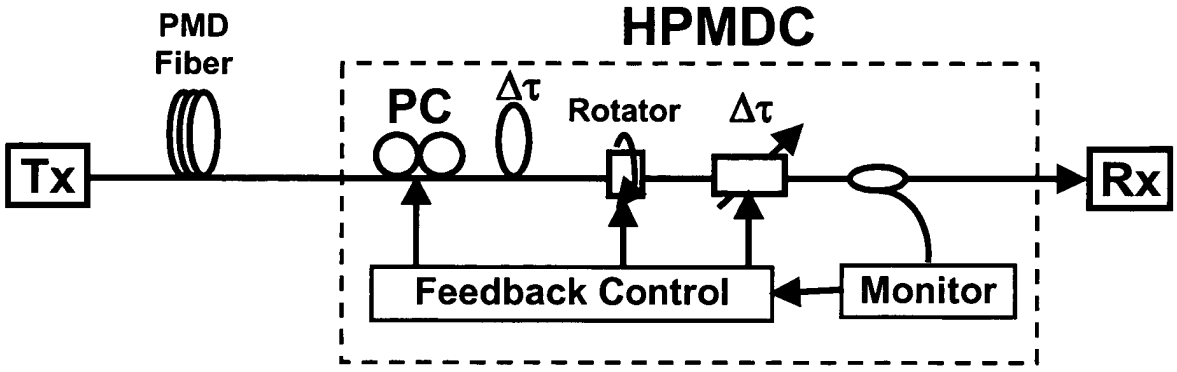

PMD
Fiber
HPMDC
PC
Δτ
Rotator
Δτ
Tx
Rx
Feedback Control
Monitor

FIG. 35

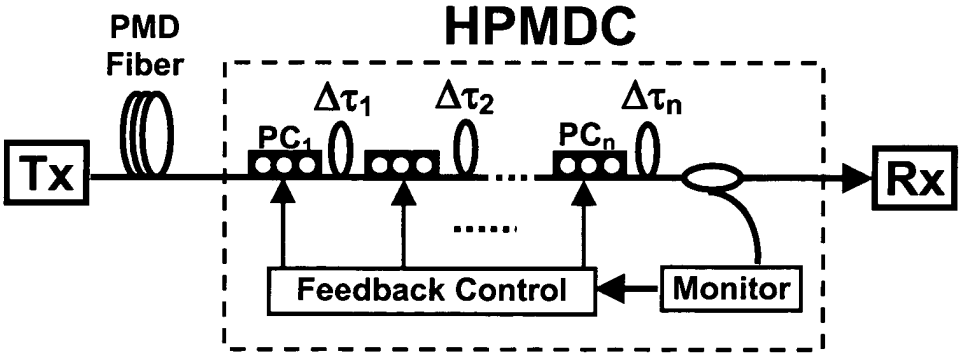

PMD
Fiber
HPMDC
Δτ1
Δτ2
Δτn
PC1
PCn
Tx
Rx
Feedback Control
Monitor

FIG. 36

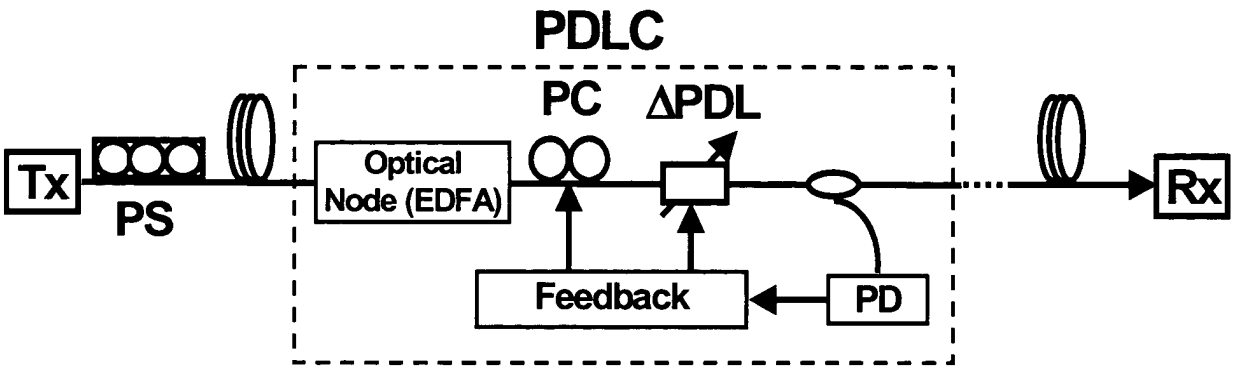


FIG. 37A

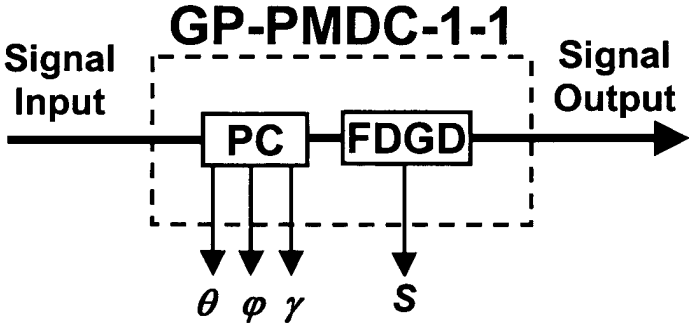


FIG. 37B

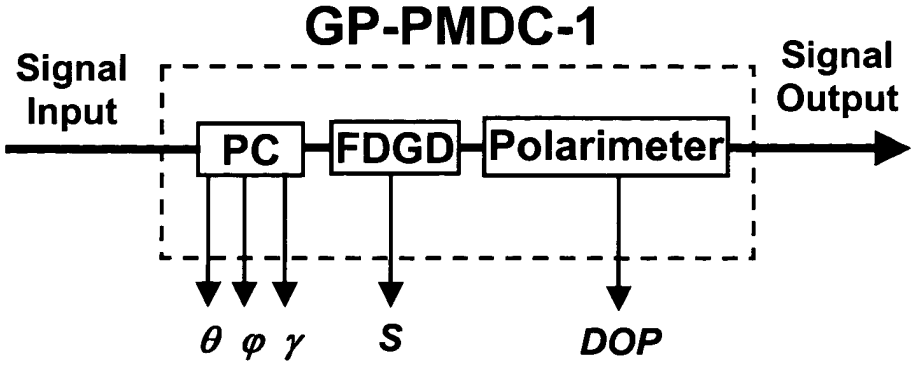


FIG. 38A

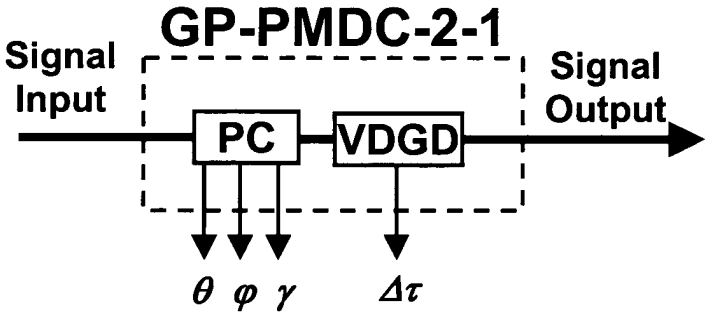


FIG. 38B

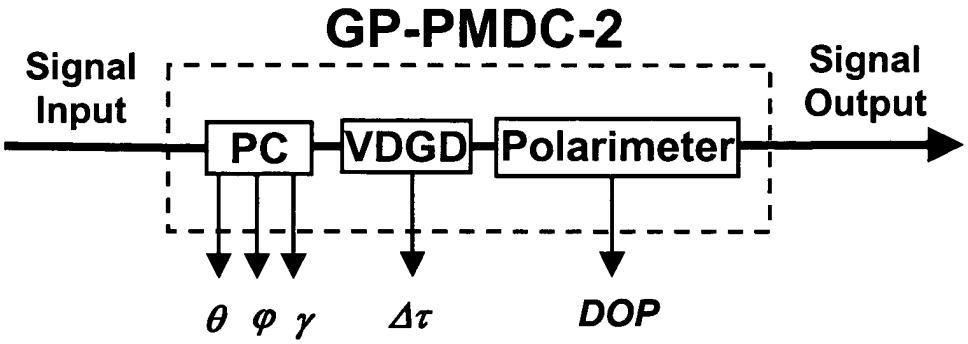


FIG. 39A

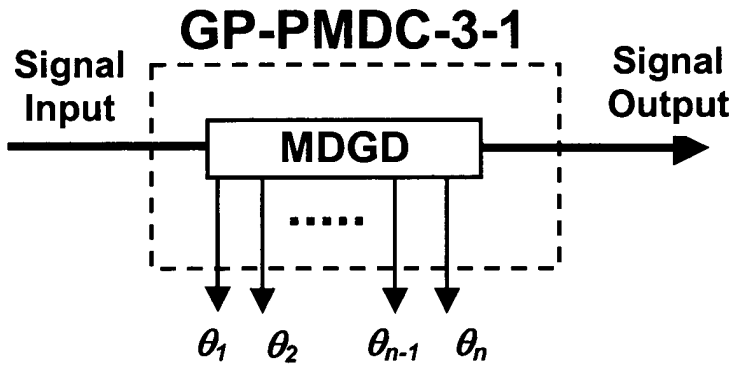


FIG. 39B

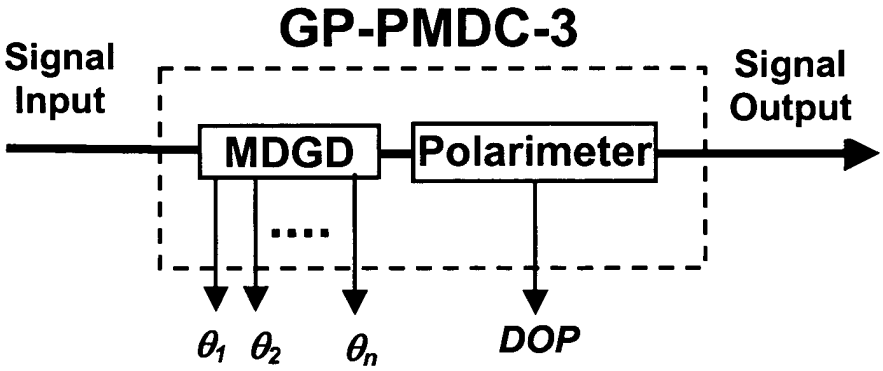


FIG. 40A

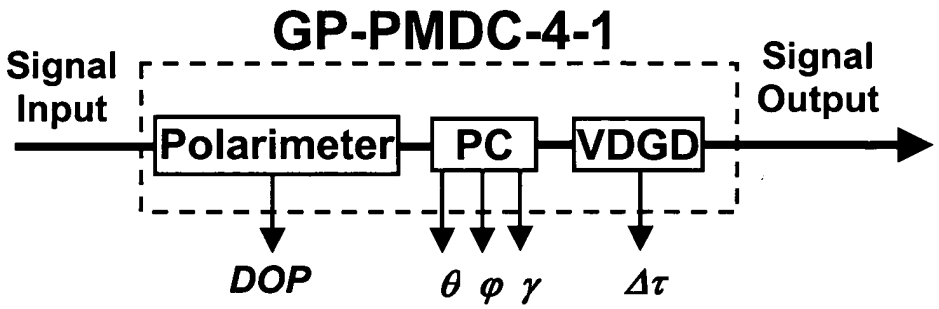


FIG. 40B

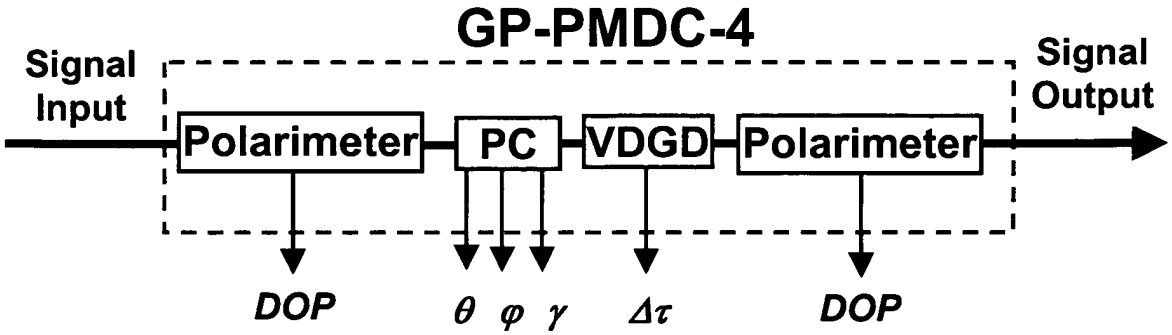


FIG. 41A

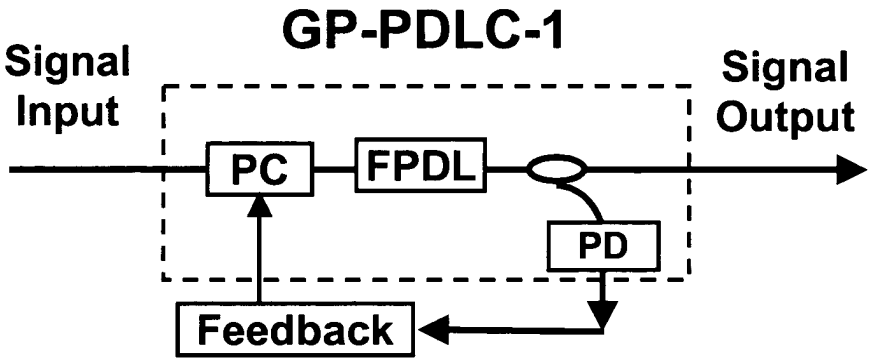


FIG. 41B

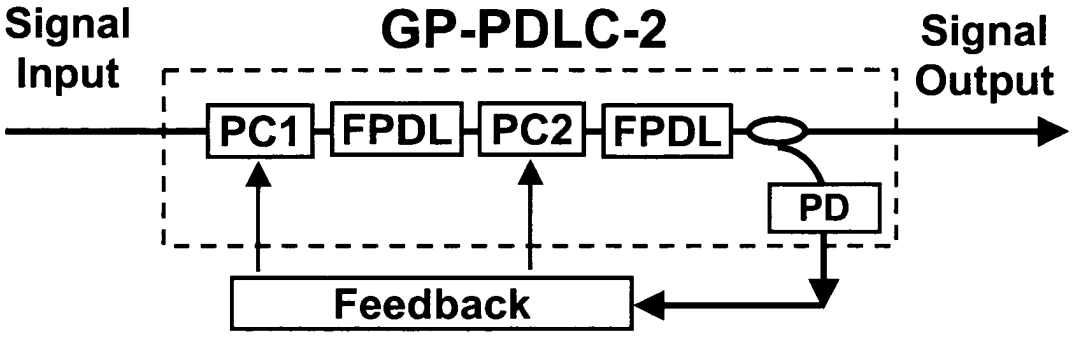


FIG. 42A

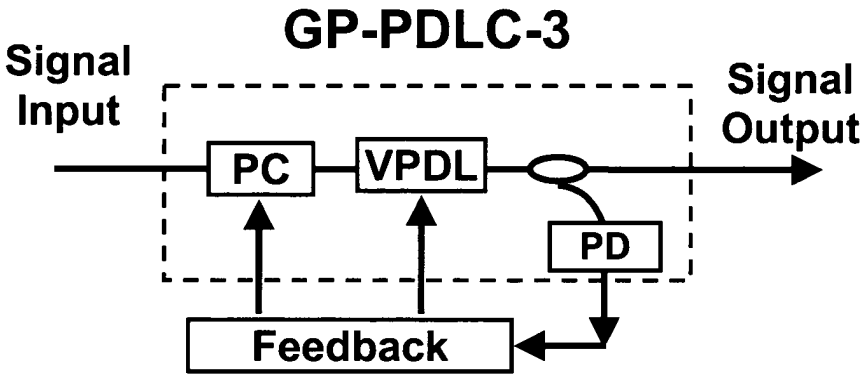
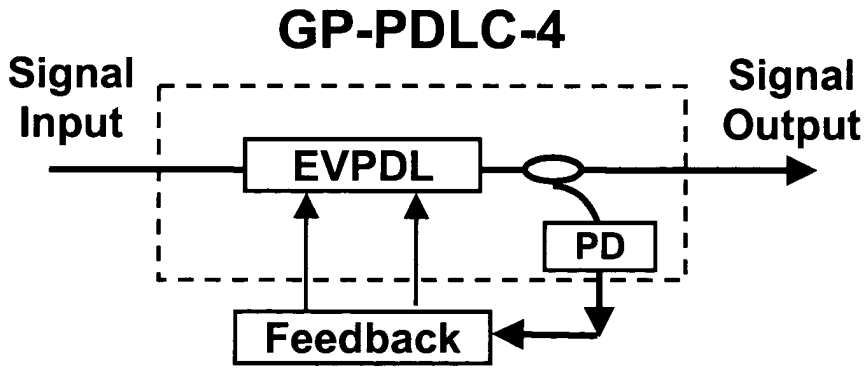



FIG. 42B